



A Review on Importance of *Artocarpus heterophyllus* L. (Jackfruit)

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Abstract

The Jackfruit (*Artocarpus heterophyllus* L.) is well-known as “poor man’s food” fruit in Bangladesh. It is widely consumed by most of the rural people and it is the national fruit of Bangladesh. The main aim of this review is to document the medicinal significance of jackfruit (*Artocarpus heterophyllus* L.), major parts and uses of the jackfruit in Bangladesh. This article was based on mostly a literature review. All parts of the fruit and plant are used as human food, animal feed and wood source for furniture. Although jackfruit is the main fruit of the tree, it is used as furniture for its beautiful texture and wood color. Jackfruit contains anti-bacterial, anti-diabetic, anti-oxidant, anti-inflammatory and anti-helminthic properties. The fruit is rich in carbohydrates, minerals, carboxylic acids, dietary fiber, vitamins and minerals. The seed is rich in manganese, magnesium, potassium, calcium iron and lectins and thus meets up nutritional requirements for the rural people. The present study attempted to review the medicinal importance, health-promoting effects of jackfruit and seeds with special emphasis on their applications in the food.

Keywords: jackfruit, medicinal importance, fruit and seed quality, health benefits, morphology

1. INTRODUCTION

Artocarpus heterophyllus is the scientific name of jackfruit which the fruit belong to the family of Moraceae and native to Southeast Asia [1]–[3]. It is widely cultivated in most tropical countries like Bangladesh, India, Burma, Philippines, Pakistan, Sri Lanka, Malaysia, Thailand, and several areas in Brazil, Queensland, Africa and some other parts of Australia and America. Bangladesh is sanctified with a vast diversity of fruits. About 70 different types of fruits are grown in Bangladesh [4]. Jackfruit is the national fruit of Bangladesh [5][6] and mango is our national plant of Bangladesh [7]. It is the major fruit tree at Madhupur tract in Bangladesh [8]. The edible fruit of jackfruit is known as the “poor man’s food” [9][10]. It is the most popular fruit in rural and urban areas of Bangladesh. It ranks the 4th

position as per production volume after banana, mango, and pineapple [11]. Jackfruit ranks the 3rd position with respect to fruit production in Bangladesh.

There are so many benefits from the fruit, tree, branches of jackfruit. The fruit is enriched with a diverse of nutrients and edible where the fruit can be consumed when its ripe and when its green part uses as vegetable. The edible bulbs of ripe jackfruit are usually consumed fresh or processed into canned products; 10-15 percent of the total fruit weight is considered as its seed weight. In Asia, folk consume the plants in medicine and used as anti-bacterial, anti-diabetic, anti-oxidant, anti-inflammatory and anti-helminthics properties [12]. Approximately, 2 Megajoule energy per kg/wet weight of ripe perianth. Besides, the fruit can supply at [13]. Phytonutrients contain in jackfruit such as lignans, flavones and saponins have the properties of anticancer, antiulcer, antihypertensive and antiaging [14]. The fruit is rich in carbohydrates, minerals, carboxylic acids, dietary fiber, vitamins and minerals. The seed is rich in manganese, magnesium, potassium, calcium iron and lectins and thus meets up nutritional requirements for the rural people. The jackfruit seed flour is not only a rich source of protein, starch and dietary fibers but can also be regarded as an abundant yet cheap source of nutrients. Lectin, a class of glycoprotein found in jackfruit seed, has been reported to possess antibacterial, antifungal

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Table 1. Keyword search

No.	Keyword Search	Articles Number
1	<i>Artocarpus heterophyllus</i> L. or Jackfruit	215
2	Medicinal importance	188
3	Fruit and seed quality	218
4	Health benefits	114
5	Morphology	225
6	Limit of article	201
7	Manually screened	87
8	Articles included in the review	60

and anticarcinogenic properties [15]. Ripe jackfruit pulp is processed, dehydrated and sold as dry powder which is utilized for juice, biscuits, chutney, jam, jelly, toffee, paste, leather, bar, nectar, squash and pickle [16]. It is also canned in syrup, either plain or blended with dehydrated bulbs, chutney, preserves, candy and concentrate and powder. Now a days, consumer preferences have changed to diets with more natural antioxidants, dietary fibers, natural colorants, minerals, vitamins, reduced calories, low cholesterol and low sugar, free of chemicals, etc. The possibilities of utilizing jackfruit waste and by product of leaves and wood for production of biogas, briquettes and biochar [17]. Jackfruit growth and development are directly depended on the source of nutrients and those nutrients improve the nutritional quality of jackfruit [18].

The qualitative jackfruit and some seeds are exported to UK [19]. The jackfruit is a cross pollinated fruit tree and is mainly propagated by seeds [20]. The tree as well can provide many other uses in environmental protection. The leaves of the jackfruit tree are used as nutritious food for cattle. The leaves are rich in vitamins and minerals which are important for the animal. Its remaining stalks are used as wood. However, the main stem enhances the beauty of the house as furniture. It is possible to earn income by selling wood as wood, just as it is possible to make a lot of profit by selling well shape wood. However, a lot of money is earned by selling ordinary jackfruit fruits. But the jackfruit trees cultivated around the village house are not taken care of but no fertilizer is given. By considering the above points, the present study was undertaken to collect information about the significance of the nutritional and medicinal

importance of jackfruit in Bangladesh.

2. METHODOLOGY

To assess the current state of the research on importance of jackfruit (*Artocarpus heterophyllus* L.), a review of the existing journal literature, books, report, blogs and newspaper were carried out. Keywords (Jackfruit, medicinal importance, fruit and seed quality, health benefits, and morphology) search in the google, google scholar, web of science database (www.thomsonreuters.com/web-of-science) and a full-text search of the Science Direct (www.sciencedirect.com) database were carried out. Information was also collected from government organization and NGO's by personal communication. The reviews or literature reviews will be examined to identify further studies for inclusion, and the results of meta-analyses will not be included in the analysis.

3. MORPHOLOGY OF JACKFRUIT

3.1. Size and Shape

Jackfruit grow as an evergreen tree that has a relatively short trunk with a dense treetop. It easily reaches heights of 10 to 20 m (33 to 66 feet) and trunk diameters of 30 to 80 cm (12 to 31 inches). The canopy shape is usually conical or pyramidal in young trees and becomes spreading and domed in older trees (Figure 1). It sometimes forms buttress roots. The bark of the jackfruit tree is reddish-brown and smooth. In the event of injury to the bark, a milky juice is released. In young trees, the leaf edges are irregularly lobed or split. The tree casts a very dense shade. Heavy side branching

usually begins near the ground. All parts of the tree exude sticky white latex when injured.

3.2. Flowers

This species is monoecious, having male and female inflorescences (or “spikes”) on the same tree. The flowers are small, sitting on a fleshy rachis. Male and female spikes are borne separately on short, stout stems that sprout from older branches and the trunk. The male flowers are greenish, some flowers are sterile (Figure 1). Male spikes are found on younger branches above female spikes. Male spikes are dense, fleshy, cylindrical to club shaped, and up to 10 cm (4 in) in length. Flowers are tiny, pale green when young, turning darker with age. The male flowers are less and small hairy and the perianth ends with two 1 to 1.5 mm ($\frac{3}{64}$ to $\frac{1}{16}$ in) membrane. After the pollen distribution, the stamens become ash-gray and fall off after a few days.

Female flowers are larger, elliptic or rounded, tubular calyx, with hairy and tubular perianth, have a fleshy flower-like base. The female flowers contain an ovary with a broad, capitate or rarely bilobed scar (Figure 1). The flowers are reportedly pollinated by insects and wind, with a high

percentage of crosspollination. The blooming time ranges from December until February or March [21].

3.3. Fruit

The inflorescences are formed on the trunk, branches or twigs (cauliflory). Jackfruit trees are monoecious, having both female and male flowers on a tree. Fruit of jackfruit has a compound or multiple fruit with a green to yellow brown exterior rind that is composed of hexagonal, bluntly conical carpel apices that cover a thick, rubbery, whitish to yellowish wall (Figure 1). The ellipsoidal to roundish fruit is a multiple fruit formed from the fusion of the ovaries of multiple flowers. The fruits grow on a long and thick stem on the trunk. The heavy fruit is held together by a central fibrous core. They vary in size and ripen from an initially yellowish-greenish to yellow, and then at maturity to yellowish-brown. They possess a hard, gummy shell with small pimples surrounded with hard, hexagonal tubercles. The large and variously shaped fruit have a length of 30 to 100 cm (10 to 40 inches) and a diameter of 15 to 50 cm (6 to 20 inches) and can weigh 10–25 kg (22–55 pounds) or more [22].

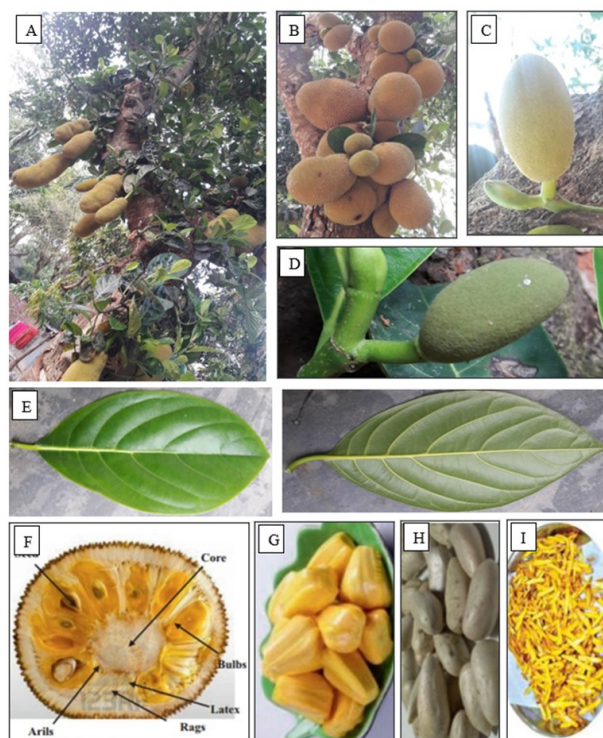


Figure 1. (a) Jackfruit tree with the fruits; (b) jackfruit tree with the fruits in different stages of fruiting; (c) club shaped spike male inflorescence; (d) female inflorescence; (e) leaf showing both side (f) Cut section of jackfruit; (g) the bulbs of jackfruit; (h) the jackfruit seed and (i) Jackfruit Chips

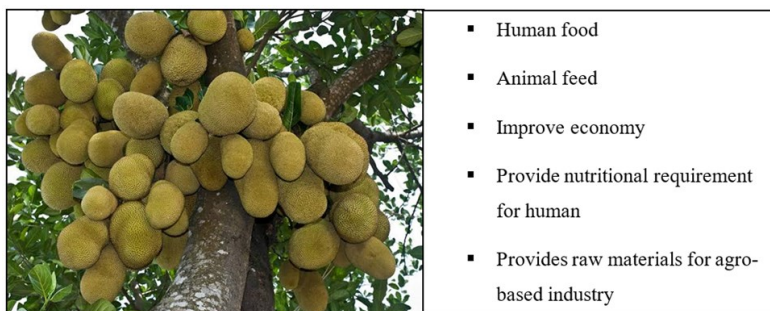


Figure 2. Diversified uses of Jackfruit plant, fruits and by products [30]

3.4. Leaves

Leaves are dark green, alternate, entire, simple, glossy, leathery, stiff, large (up to 16 cm [6 in] in length), and elliptic to oval in form. The leaves are alternate and spirally arranged (Figure 1). They are gummy and thick and are divided into a petiole and a leaf blade. On older trees, the leaves are rounded and dark green, with a smooth leaf margin. The petiole is 2.5 to 7.5 cm (1 to 3 inches) long. The leathery leaf blade is 20 to 40 cm (7 to 15 inches) long, and 7.5 to 18 cm (3 to 7 inches) wide and is oblong to ovate in shape. Leaves are often deeply lobed when juvenile and on young shoots.

3.5. Seeds

Seeds are light brown, rounded, 2–3 cm (0.8–1.2 in) in length by 1–1.5 cm (0.4–0.6 in) in diameter, and enclosed in a thin, whitish membrane. There may be about 100–500 seeds per fruit (Figure 1). Seeds are recalcitrant and can be stored up to a month in cool, humid conditions [21]. The seed coat consists of a thin, waxy, parchment-like and easily removable testa (husk) and a brownish, membranous tegmen. The cotyledons are usually unequal in size, and the endosperm is minimally present. An average fruit consists of 27% edible seed coat, 15% edible seeds, 20% white pulp (undeveloped perianth, rags) and bark and 10% core [7].

4. MAJOR PARTS OF A JACKFRUITS

Jackfruit has three main parts [2], the fruit axis, the perianth and the bulbs. The axis contains the core, latex and the arils (Figure 1). Jackfruit has lactiferous cells which are responsible for production of latex [23], which is sap that sticky in nature. The perianth contains the rind and the rags, the bulbs contain the edible part and the seeds. The inedible parts of jackfruit include prickly rind, non-

edible perianth and a central core [24]. All these inedible jackfruit parts are potential raw materials for bioenergy and biochar production.

5. USES OF THE JACKFRUIT PARTS

All parts of the fruit and tree are used as human food, animal feed and wood source for furniture (Figure 2). The jackfruit pulp is processed for juice, biscuits, chutney, jam, jelly, toffee, paste, leather, bar, nectar, squash and pickle. The color and flavor are important for the jackfruit bulb [25]. Ice-cream prepared by using the jackfruit bulbs. The green fruit bulbs and seeds used as cooking materials in the farmers community. The leaves use as animal feed and the leaves are contain significant amount of nutrients. The wood materials are using as furniture of home and possibilities of utilizing jackfruit waste and by product of leaves and wood for production of biogas, briquettes and biochar which is applied in the farmer's field. The jackfruit bulbs are using in bakery industry which is improve the food quality. The bakery products are increasingly gaining popularity since they are convenient, readily available in diverse tastes and textural profiles, less expensive and possess high nutritive value. The bakery products are as biscuits [26], cookies, bread [27], cake [28], muffins [29] etc. have been formulated by supplementation with different levels of jackfruit seed flour. So, there is scope to develop the industry which is help in employment sector in Bangladesh.

6. MEDICINAL SIGNIFICANCE OF JACKFRUIT

The *Artocarpus* species have been used as traditional medicines. The plants have been used as anti-bacterial, anti-diabetic, antioxidant, anti-inflammatory and anti-helminthic [31]. Jackfruit is

also a rich source of many minerals such as N, P, K, Ca, Mg, S, Zn, Cu, etc. [32]. The nutritional parameters of the jackfruit flesh, seeds and the meal are presented in Table 2. The water contents of the young, ripe fruit and seeds were (51.0-94.4) g; respectively. The available digestible carbohydrate contents of the young, ripe fruit and seeds were (16.0-38.40) g; respectively. Jackfruit seeds are underutilized and less acknowledged by people, but they have considerable nutritional benefits and constitute about 10% to 15% of the fruit weight [33]. The protein content of the meal was (0.40-2.60) g the young, ripe fruit and seeds of jackfruit; respectively with a higher contribution from the young fruit while the fat content of the meal was (0.10-0.60) g in the young, ripe fruit and seeds; respectively. The fiber content of the meal was (1.0-2.60) g the young, ripe fruit and seeds of jackfruit; respectively with a higher contribution from the young fruit while the mineral content of the meal was (0.87-0.90) g in the young, ripe fruit and seeds; respectively. The ripe fruit contains 20.60 g sugar in the meal. The jackfruit rich in calcium, magnesium, phosphorus, potassium, sodium, iron, vitamin A, thiamine, riboflavin and vitamin C (Table 2). Jack seeds contained high total dietary fiber (TDF) (11.1%) compared to flesh (2.6%). Jackfruit seeds also contained 8% resistant starch (undigestible starch).

It is a major source of carbohydrates, minerals and vitamins [34]. Hasan et al. [35] reported that the average annual net returns found more than the agriculture system. Alves et al. [36] observed that the fruit contains lignins, flavones and saponins which have the properties of anti-cancer, anti-ulcer, anti-hypertensive and anti-aging. It contains immense medicinal values and also considered a rich source of carbohydrates, minerals, carboxylic acids, dietary fiber and vitamins such as ascorbic acid and thiamine [13]. Manganese and magnesium [32], potassium, calcium and iron [37] elements are found in seed. Mukprasirt and Sajjaanantakul [38] reported that the seeds contain lectins as jacalin and artocarpin. Jacalin has been shown to be useful for the evaluation of the immune status of patients infected with human immunodeficiency virus [39]. Seed nanoparticles were found effective against *Escherichia coli* and *Bacillus megaterium* bacteria [40]. It has anti-oxidant action [3], and acts against inflammation, malarial fever and skin diseases [41], anti-bacterial and anti-helminthic [42]. The tree leaves are commonly used as healing for ulcer. Its leaves have the potential of curing diabetics due to the presence of hypoglycemic and hypolipidemic substances [43]. The leaves and stems have sapogenins, cyclooctenone, cycloartenol, β -sitosterol and tannins. The latex yield artosteron mixed with vinegar promotes healing of glandular

Table 2. Nutrient composition of jackfruit (100 g edible portion)

Nutrients	Young fruit	Ripe fruit	Seed
Water (g)	76.20-85.20	72.0-94.0	51.0-64.50
Protein (g)	2.0-2.60	1.20-1.90	0.40-0.43
Fat (g)	0.10-0.60	0.10-0.40	0.40-0.43
Carbohydrate (g)	9.40-11.50	16.0-25.40	25.80-38.40
Fiber (g)	2.60-3.60	1.0-1.50	1.0-1.50
Sugar (g)	-	20.60	-
Minerals (g)	0.90	0.87-0.90	0.90-1.20
Calcium (mg)	30.0-73.20	20.0-37.0	50.0
Magnesium (mg)	-	27.0	54.0
Phosphorus (mg)	20.0-57.20	38.0-41.0	38.0-97.0
Potassium (mg)	287-323	191-407	246
Sodium (mg)	3.0-35.0	2.0-41.0	63.20
Iron (mg)	0.40-1.90	0.50-1.10	1.50
Vitamin A (IU)	30	175-540	10-17
Thiamine (mg)	0.05-0.15	0.03-0.09	0.25
Riboflavin (mg)	0.05-0.20	0.05-0.40	0.11-0.30
Vitamin C (mg)	12.0-14.0	7.0-10.0	11.0

Source: Goswami and Chacrabati [34]

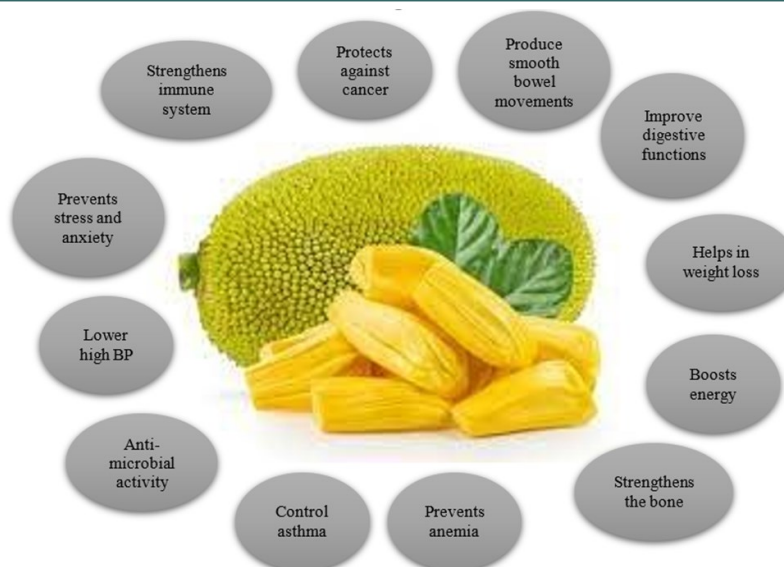


Figure 3. Health benefits of jackfruit

swelling and snake bites [44]. Long et al. [45] reported that the root extract is a therapy for asthma and skin disorder. The wood has sedative property and believed that it may cause promotion of abortion cure diarrhea and fever [46]. The fruits and roots are used for tapeworm infection [47]–[49]. The fruit is rich in carbohydrates, complex B vitamins, and minerals [50]. The freshly fruit is consumed. It can be processed to candies, sweets, frozen pulps, juices and vegetable in immature fruit. Its seed can be consumed as baked or used in culinary to develop several menus. Now, there are studies concerning the use of seed meal for preparing cookies, sweets and bread as an alternative source of carbohydrate. The jackfruit contains variable constituents of moisture (6.7%), glucosides (38.0%), lipids (0.7%), protein (1.7%) and cellulose (59.0 %) [50]. Jagtap and Bapat [51] observed that the ripe fruits are rich in nutritive value; every 100 g of ripe fruit contains 287–323 mg potassium, 30.0–73.2 mg calcium and 11–19 g carbohydrates. Chowdhury et al. [52] reported that the bark contains betulinic acid and a flavone pigment, cycloheterophyllin ($C_{30}H_{30}O_7$). The fruit pulp also contains lycopene [53]. De-Faria et al. [54] reported that the fruit contain 18 carotenoids were successfully separated, identified and quantified and 14 were detected. The leaves and stem contain saponins, cycloartenone, cycloartenol, β -sitosterol and tannins show estrogenic activity. A root contains β -sitosterol, ursolic acid, betulinic acid and cycloartenone [4]. Jackfruit seed contains a thin brown spermoderm,

the crude fiber (2.36 %), but the composition of flour depends on nature of seed [55].

7. HEALTH BENEFITS OF JACKFRUIT SEEDS

The phytonutrients such as lignans, saponins, and isoflavones present in the seeds, plays beneficial role in human health presented in Figure 3 [55]. The presence of high fiber content (3.6 g/100 g) in the jackfruit improve digestion system and produces smooth bowel movements. It also offers protection to the colon mucous membrane by removing carcinogenic chemicals from the large intestine [30].

The addition of the jackfruit seed flour to deep-fried products results in a reduction in fat absorption up to a certain limit [56]. The seeds are rich in dietary fiber and B-complex vitamins and due to their high fiber content, they help lower the risk of heart disease, prevent constipation and promote weight loss. Jackfruit seeds also contain resistant starch, which controls blood sugar and keeps the gut healthy. Jackfruit seeds possess anti-microbial activity, which prevents foodborne diseases [54] and the seeds contain an important lectin known as jacalin, used as a tool to evaluate the immune system of an HIV infected person. In China the seeds are known to be beneficial in overcoming the toxicity due to alcohol and likewise, in India, the seeds are a crucial component of an antidote produced for heavy drinkers [57]. The seeds contain an abundance of magnesium

which plays a vital role in lowering the blood pressure and maintaining bone health since it aids in calcium absorption and hence helps to strengthen the bones [2]. Furthermore, the seeds are rich in highly soluble protein resulting in the prevention and treatment of mental stress and anxiety. The seeds have low water and fat-absorption capacities, which helps in prevention of obesity [58]-[60].

8. CONCLUSION

Jackfruit is quite versatile. It can be eaten raw, cooked, ripe or unripe and tastes great in a variety of sweet and savory dishes. The consumption of jackfruit has grown in recent years due to its reported health benefits. Jackfruit and its pulp and seeds are rich sources of several high-value compounds with potential beneficial health benefits. The rich bioactive profile of jackfruit makes it a highly nutritious and desirable fruit crop. The review concluded that all the nutrients like vitamins and minerals fulfill malnutrition in the rural area of Bangladesh.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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